

K-wire and tension band wire fixation in treating sternoclavicular joint dislocation

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【Abstract】Objective: To evaluate the feasibility and therapeutic effect of treating sternoclavicular joint dislocation by K-wire and tension band wire fixation, and to improve the safety and stability of this technique.

Methods: This study consisted of 9 cases, 6 males and 3 females with the mean age of 25 years (range, 9-62 years). The causes were traffic accident in 7 cases, falling in 1 case and fight in 1 case. The duration from injury to operation was 2 hours to 7 days. There were 5 left dislocations and 4 right dislocations; 8 anterior dislocations and 1 posterior dislocation, including one combined with left scapular fracture and one with left olecranon fracture. Open reduction and internal fixation using K-wires and tension band wires were performed to treat dislocations.

Results: All patients were followed up for 6 to 24 months, 10 months on average. According to Rockwood's

rating scale on postoperative sternoclavicular joint, 8 cases achieved excellent outcomes with an average score of 13.88, and the rest case achieved a good outcome with the score of 12. Anatomical reduction was obtained in all cases. There were no such postoperative complications as severe infection, injury to blood vessel and nerve, failure of fixation, etc. Patients were all satisfied with the anatomical reduction and functional recovery.

Conclusions: The technique of K-wire and tension band wire fixation is safe, simple, effective, less invasive and has been successfully used in orthopedic surgery. It is effective in treating sternoclavicular joint dislocation though it has some disadvantages.

Key words: *Sternoclavicular joint; Dislocations; Bone wires; Fracture fixation, internal*

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S ternoclavicular joint dislocation is a rare joint injury and traumatic sternoclavicular joint dislocation accounts for less than 5% in all injuries of the scapular belt¹ and less than 1% in all dislocations². Injuries to the sternoclavicular joint are uncommon, probably because the sternoclavicular joint locates in the midline region of the body rather than the joint has a poor stability.³ Posterior sternoclavicular joint dislocation is rarer than anterior dislocation and a ratio as high as 20:1 has been reported.⁴ Sternoclavicular joint dislocation can be easily managed by open reduction. But unfortunately the reduction is unstable and redislocation usually happens. Open reduction combined

with internal fixation is the most commonly used technique and there are many ways to complete this technique.^{5,6} However, it has the complication of dislocation deformity and several other limitations, particularly when the situation is very complex, e.g. combined with clavicular fracture. In order to improve the therapeutic effect and reduce complications, we treated sternoclavicular joint dislocation by K-wire and tension band wire fixation.

METHODS

Clinical data

Totally 9 cases, including 6 males and 3 females with the mean age of 25 years (range, 9-62 years) were included in this study. The causes were traffic accidents in 7 cases, falling in 1 case and fight in the rest case. The duration from injury to operation was 2 hours to 7 days. There were 5 left dislocations and 4 right dislocations, or 8 anterior dislocations and 1 posterior dislocation. Among them, one was combined with left scapular fracture and another one combined with left olecranon fracture. All the patients presented with swell-

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ing of the injured sternoclavicular joint, local pain and obvious tenderness. Activities of the sternoclavicular joint were largely limited. The anterior dislocation was characterized by obvious protruding joint (Figure 1) and abnormal movements. Vacancy was felt in the anterior surface of the sternoclavicular joint that was dislocated posteriorly.

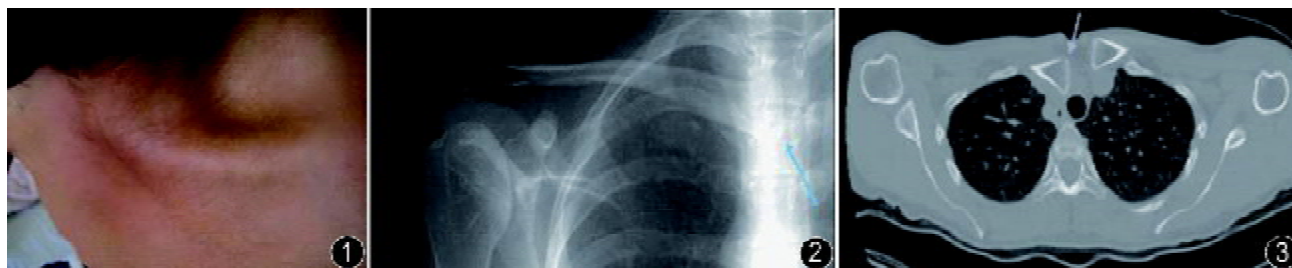


Figure 1. The anterior dislocation is characterized by obvious protruding joint. **Figure 2.** Anterior-posterior radiograph of the right clavicle. The arrow shows displacement. **Figure 3.** Non-contrast CT of the chest. The arrow shows posterior dislocation of the right medial clavicle with encroachment on the trachea.

Surgical procedures⁷

After general anesthesia, the patient lied on the operating table in supine position with 3-4 towels or a small sandbag placed between the scapulae. The skin incision, which was about 8-10 cm long, began cephalad to the superior border of the medial aspect of the clavicle and extended to the notch of the manubrium and it went caudad 3-4 cm onto the anterior surface of the manubrium. A deep incision was made along the medial 4-5 cm of the clavicle across the capsular ligament and caudad onto the manubrium. The sternal head of the sternocleidomastoid muscle can be preserved and the clavicular head was exposed. The capsular ligament was opened carefully to expose the joint. The capsular ligament and the intra-articular disc ligament were debrided to expose the sternoclavicular joint. However, if the intra-articular disc ligament was intact, it was preserved for stabilization of the joint at the time of closure, but it should be resected if it was severely damaged.

At 2 cm off the medial clavicle, a hole was made and the wire was driven through the hole. Two 2 mm K-wires were crossly introduced into the articular surface of the sternum at a 20° inclination angle between the sternum and the needles. After reduction, the two K-wires were placed into the clavicle, not hurting the important structures behind the clavicle. One needle was drilled into the marrow and the other penetrated through the clavicle cortex. K-wires were bound and fixed by wires like figure-of-8. The excessive part of the K-wires was cut off and the remaining was bended to prevent displacement, and finally the incision was sutured (Figures 5 and 6).

X-ray films of the chest showed anterior or posterior displacement of the medial clavicle (Figure 2) and change of the joint space (Figure 3). Three-dimensional CT scan demonstrated dislocation of the left posterior sternoclavicular joint and venous impingement (Figure 4).

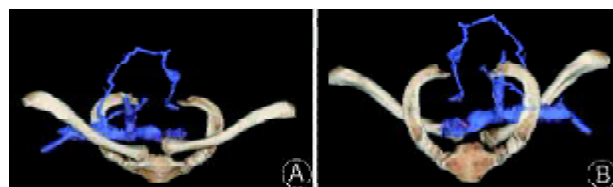


Figure 4. Three-dimensional CT scan films demonstrate dislocation of the left posterior sternoclavicular joint with venous impingement.

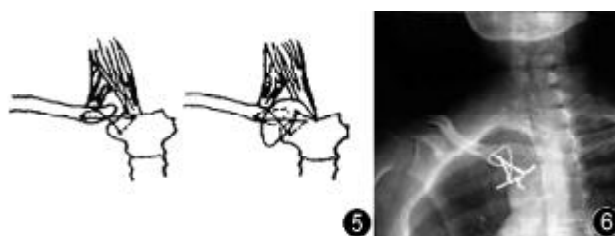


Figure 5. Schematic diagram of the surgical technique. **Figure 6.** Postoperative photographs of the figure-of-8.

Good care should be taken in dissociating the sternum to avoid injuring deep blood vessels and the pleura. The periosteum was dissected carefully off the medial portion of the clavicle when the periosteum was carefully preserved for the following closure and the costoclavicular ligament was also preserved. The injured joint disc, whose function was similar with that of meniscus, should not be removed. The rib-clavicular joint disc, which had a moderate range of motion, should be repaired. External fixation was not necessary, but scarf bandage should be kept for a week and abduction activities should be limited. Functional training of the upper extremity can be carried out at 12 weeks after surgery when internal fixator was removed. Patients with scapular fracture or

olecranon fracture underwent open reduction and internal fixation, additionally.

RESULTS

All patients were followed up for 6 to 24 months, 10 months on average. The outcomes were satisfactory in all patients. Sternoclavicular joint position was normal and no dislocation, local tenderness or loosening of joints was observed. The upper extremity activities and functions were excellent. According to the rating scale on postoperative sternoclavicular joint in the study of

Rockwood et al⁷, the outcomes were regarded as excellent in 8 cases (average score=13.88) and good in the rest case (score=12). The detailed scores in terms of pain, range of motion, strength, limitation, subjective result and total score are listed in Table 1. There were no such postoperative complications as severe infection, injury to the blood vessel and nerve, failure of fixation, etc. All dislocations achieved anatomical reduction. All the patients, including those combined with scapular fracture and olecranon fracture, were satisfied with the appearance and functional recovery.

Table 1. Evaluation of the postoperative sternoclavicular joint based on Rockwood's rating scale (n=9)

Case	Gender	Age (years)	Preoperative diagnosis	Duration of follow-up	Scores on rating scale (points)					
					Pain	Range of motion	Strength	Limitation	Subjective results	Total scores*
1	M	19	anterior	7	2	3	2	3	3	13
2	M	27	anterior	6	3	3	3	2	3	14
3	M	9	anterior	12	2	3	3	2	3	13
4	F	23	anterior	9	3	3	3	2	3	14
5	M	16	posterior	10	3	3	2	3	3	14
6	F	30	anterior	8	3	3	2	2	3	13
7	M	62	anterior	24	3	2	3	2	2	12
8	F	21	anterior	8	3	3	3	3	3	15
9	M	18	anterior	6	3	3	3	3	3	15

*A total score of 13, 14, or 15 points indicates an excellent result; 10, 11, or 12 points, a good result; 7, 8, or 9 points, a fair result; and less than 7 points, a poor result. M=male and F=female.

DISCUSSION

Sternoclavicular joint is the only synovial joint connecting the upper extremity and the trunk and it is an amphiarthrosis consisting of clavicular notch of sternum, first rib and medial clavicle. The stability of the joint depends largely on the integral articular disc, joint capsule and the surrounding ligaments. Due to the bony structure, it is one of the most unstable joints.^{8,9} The anterior sternoclavicular ligament is weak and locates at the tension side of the joint capsule. It bears traction force when indirect force is applied on the clavicle. Besides, because of the leverage when the force acts on the first rib, anterior dislocation of the joint is common, while posterior dislocation is rare.¹⁰ Indirect external force is the most common cause of dislocation, resulting in deformity. Severe pain, swelling, restricted movements of upper extremity and facial sympathetic symptoms may occur through sympathetic reflexion when the medial clavicle stimulates the C₁₋₅ postgan-

glionic fibers which extend to the trachea and esophagus. Injuries associated with posterior dislocation include compression or laceration of the great vessels, tracheal compression or rupture, esophageal compression or rupture, injury to the brachial plexus and pleural disruption, which may lead to pneumothorax or subcutaneous emphysema.¹¹ There are three factors contributing to dislocation: (1) variation of the angle between sternoclavicular joint and sagittal plane; (2) passive range of motion and size of the joint space; and (3) clavicle dislocation and sternoclavicular joint subluxation during arm flexion and adduction under external force applied on the shoulder.¹²

Correct diagnosis can be made based on history, symptoms and signs and X-ray films, but missed diagnosis easily happens if it is combined with multiple injuries. X-ray examination also has limitations, resulting in difficulty in diagnosis. CT scan plays an important role in diagnosis,^{4,13} by which anterior or posterior dislocation,

and oppression of the major nerves or blood vessels can be confirmed immediately¹⁴. And the spiral CT 3D reconstruction is able to provide particularly clear images.^{15,16}

Sternoclavicular joint dislocation is an injury of the joint capsule and surrounding ligaments. It destructs the joint stability. Redislocation can easily happen. Furthermore, contraction of the muscles attached to the clavicle can easily cause redislocation after reduction. Some scholars advocate nonsurgical treatments,¹¹ but patients feel uncomfortable and the muscle strength is weakened when the shoulder abducts. There are some complications of traditional treatments. (1) Reduction can be easily achieved but hard to maintain, which leads to subluxation deformity, limitation of joint activity and function, etc. (2) Medial clavicle resection is pretty invasive with severe postoperative pain and bone defects. Removing the costoclavicular ligaments will cause the loss of joint stability, furthermore, loss of the only link between trunk and upper extremity, leading to poor postoperative stability.

Plate fixation accompanies greater damage and severe complications. It is not suitable for children. Although the fixation is firm, joint activities are limited and functional exercises would cause stress concentration, resulting in failure of the internal fixation. We advocate open reduction and internal fixation with K-wires. Meanwhile, damaged ligaments should be repaired in order to get further fixation.

The method has the following advantages. (1) It can achieve anatomical reduction and repair damaged ligaments. The fixation is relatively firm and especially suitable for children whose clavicle is small. (2) The wire has sufficient strength and toughness and the figure-of-8 bandage brings firm fixation, which can enhance healing. Furthermore, the wire is flexible so that the joint can move slightly, whose effect promotes quick recovery. (3) According to the tension-band principle, two K-wires that placed through the reduced sternoclavicular joint at a certain angle help the joint fight against a variety of adverse effects at early stage. Meanwhile this contributes to the healing of articular capsule and ligaments, furthermore, it transforms adverse stress acting on the articular surface to compressive stress to reduce adverse effects. (4) The moving direction of K-wires is vertical with the sternoclavicular joint in the frontal plane and vertical with the direction of medial

clavicle dislocation, which effectively prevents redislocation. This technique overcomes the disadvantages of unsatisfactory fixed angle and danger of damaging important structures when pins penetrate from the medial clavicle to the rear. At the same time, it largely eliminates the effect of stress on K-wires and avoids failure of internal fixators caused by stress concentration because it allows a slight rotation of the sternoclavicular joint around the K-wire. (5) The healing of the joint capsule and ligaments prevents complications such as fatigue and fracture of K-wires caused by stress from upper extremity activities and respiratory movements. This increases joint stability and promotes pain relief. Furthermore, it does not cause postoperative eminence of the joint and thus patients can have good appearance of the scar. And (6) it is simple to remove the internal fixator under local anesthesia. Therefore the technique is an alternative to treat sternoclavicular joint dislocation.

Although the method is simple and less traumatic, the sternum is thin and there are some very important anatomical structures behind it, such as large blood vessels, trachea, esophagus and cupula of the pleura. Angle deviation can easily damage these structures, which has been reported clinically.^{17,18} Surgeons need to pay particular attentions to these points. (1) Operation should be gentle, especially for posterior dislocation. (2) The inclination angle and depth of K-wires when penetrating from clavicle to manubrium should be noticed. If the angle is too large or penetration is too deep, large blood vessels, trachea and other structures might be damaged, causing serious complications, even death. We advocate that the angle between needle direction and sternum be about 20°. In this study a cross insertion at the top and front of proximal clavicle which is 2-3 cm off the joint surface is made, so that each K-wire only pierces the articular cartilage surface. The exit points should be behind the central region of the articular surface, and the penetration after reduction be about 2 cm deep, most importantly, not through the sternum. (3) A small drill that drills slowly is required, and the external pressure should not be used to push the drill, so as to avoid damage of the important structures behind the sternum caused by a sudden breakthrough. It is better not to use tapped thread in case of causing loosening of K-wires. (4) The excess K-wires should be cut off intraoperatively, and the end of the K-wire should be buried under skin to

prevent wires from loosening or slipping to the rear of sternum during shoulder joint activities. And (5) follow-up is very important and patients should be timely treated when fixation fails.

However, this method still has several disadvantages:

(1) The most important one is the breakage and displacement of K-wires due to fatigue caused by the leverage effect in intense activities of upper extremity, and the K-wires can transmigrate into the mediastinum, heart, lungs and large blood vessels, which would be life threatening. Subluxation can be seen due to persistent shear stress, leading to failure of the fixation. Needling slowly, closely watching the needle angle, carefully handling K-wires, and appropriately reducing the range of postoperative upper extremity activities can avoid such complications. (2) Traumatic arthritis can be seen because K-wires have penetrated through the articular surface and may damage the articular cartilage. Also the end of the bended needle is buried under the skin and will rub the skins. After a long time, this can cause skin damage. (3) Patients can not do functional exercises early because the fixation is a little unfixable. (4) This technique can not ensure both the stability and the postoperative mobility of the reduced joint due to the articular cartilage injury caused by K-wires, which also attenuates the joint function at various degrees. (5) All K-wires that have been broken or penetrated through the joint must be removed. The process would cause loosening or sliding of the fixed wires, increase expenditures and may cause medical disputes. And (6) the traumatic scar is large compared with nonsurgical treatments, although it is smaller than that of plate fixation, leaving ugly scars thus not suitable for young women.

Open reduction and internal fixation with K-wires and tension-band wires is an effective, less invasive and relatively safe technique for sternoclavicular joint dislocation. But it still has disadvantages and better techniques are required!

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